

An extended geographical distribution of *Donax gemmula* Morrison, 1971 (Bivalvia: Donacidae): new record from the Brazilian Northeastern coast

Cristiane Xerez Barroso^{1*}, Soraya Guimarães Rabay¹, Flávio Dias Passos² and Helena Matthews-Cascon^{1,3}

1 Universidade Federal do Ceará (UFC), Centro de Ciências, Departamento de Biologia, Laboratório de Invertebrados Marinhos do Ceará. Campus do Pici, Bloco 909. CEP 60455-760. Fortaleza, CE, Brazil.

2 Universidade Estadual de Campinas (UNICAMP), Instituto de Biologia, Departamento de Biologia Animal, Caixa Postal 6109. CEP 13083-970. Campinas, SP, Brazil.

3 Universidade Federal do Ceará, Instituto de Ciências do Mar. Av. Abolição, 3207, Meireles. CEP 60165-081. Fortaleza, CE, Brazil.

* Corresponding author. E-mail: cristianexb@gmail.com

ABSTRACT: This study provides the first record of *Donax gemmula* Morrison, 1971 (Bivalvia: Donacidae) from the Ceará State, Northeast Brazil; up to now it was only known from the Southeastern and Southern Brazilian coast. Shells larger than ~2 mm in length of this species can be distinguished from those of *D. striatus* Linnaeus, 1767. Both species were collected in the same beaches: Banco dos Cajuais and Pecém. The occurrence of *D. gemmula* remains unnoticed for others States of the Northeast Brazil, and so we suggest two possible explanations for this finding from Ceará State: i) a recent introduction (e.g., by ballast water); or ii) this species has a continuous distribution along the Brazilian coast (Ceará to Rio Grande do Sul), being not recorded until now because this is not easily collected (the animals are small and bottom samples need to be sieved to obtain them) and may be confused with young specimens of other species of *Donax*, such as *D. striatus*.

Species of the genus *Donax* Linnaeus, 1758 are common inhabitants of marine tropical sandy beaches, being fast burrowers, suspension feeders which live intertidally or in the sublittoral region; some are migrants with the tidal variations (Ansell 1983). In the Brazilian coast there are four species of *Donax*, two of them (*D. striatus* Linnaeus, 1767 and *D. denticulatus* Linnaeus, 1758) recorded from the Northeastern littoral and also extending northwards to the Caribbean, while *D. hanleyanus* Philippi, 1847 and *D. gemmula* Morrison, 1971 are more restricted to the Southeastern littoral, reaching the Uruguayan or Argentinean waters (Morrison 1971; Domaneschi and Lopes 1988-89) (Figure 1A). *Donax vellicatus* Reeve, 1855 was cited by Morrison (1971) as occurring in Brazil (Rio Grande do Norte State, northeastern), but both this species and *D. denticulatus* have not been recorded since then.

Donax gemmula is the smallest of these Brazilian species, bearing a minute, smooth, subglobose shell (up to 9 mm in length), distinct from the more typical wedge shaped shell of other *Donax* species (Morrison 1971; Domaneschi and Lopes 1988-89; Passos and Domaneschi 2004). Its muscular foot provided with well-developed elevator muscles allows the species to a fast burrowing habit, living in the upper 2 cm of the sand (Passos and Domaneschi 2004), in the intertidal and upper infralittoral zones of sheltered to exposed beaches from the State of Espírito Santo (Brazil) to Uruguay (Morrison 1971). Passos and Domaneschi (2004) observed that it does not migrate with the tides. There are many ecological studies that refer to this species in the southeastern and southern Brazilian

coast (e.g. Corbisier 1991; Souza and Gianuca 1995; Borzone *et al.* 1996; Barros *et al.* 2001; Arruda and Amaral 2003; Denadai *et al.* 2005; Cochôa *et al.* 2006; Neves *et al.* 2006, 2008, 2012; Pagliosa 2006; Silva *et al.* 2008; Alves and Pezzuto 2009a, b; Neves and Bemvenuti 2009). The type locality of *D. gemmula* is Praia do Cassino, Rio Grande, Rio Grande do Sul (Morrison 1971). In the south of Bahia (a state from the Northeastern coast), the occurrence of *D. gemmula* was dubious up to now, for Ourives *et al.* (2011) recorded as "*D. cf. gemmula*", as a common species from Cachoeira River estuary, municipality of Ilhéus (Figure 1A).

This study provides the first accurate record of *D. gemmula* in the Ceará State, Northeastern Brazil. This state is about 2500 km far from Espírito Santo State, bearing 573 km of shoreline with coastal lagoons, mangroves, sandy beaches, and beaches with rock formations and/or beach rocks (Smith and Moraes 1984; Campos and Polette 2003). The specimens were collected with a PVC-made cylindrical core sampler in the intertidal zone of the Banco dos Cajuais and Pecém Beach. Banco dos Cajuais is located in the easternmost extreme of the coast of Ceará (04°41'00"S, 37°21'00"W), municipality of Icapuí (Figure 1B). It has extensive sand/mud banks in the intertidal zone (Carlos *et al.* 2010), where a total of 63 individuals of *D. gemmula* were obtained in September and November of 2008, and in February, April, May and July of 2009. At Pecém Beach (03°30'00"S, 39°50'00"W) (Figure 1B), in the western coast of Ceará, animals have been collected since 2010; here, the intertidal zone has a large sandy area

and some patches of consolidated substrate. An offshore seaport (“Terminal Portuário do Pecém”) is located in this beach. Since its construction, the sedimentary dynamics of this area have changed, with periodic processes of erosion and siltation. In both Banco do Cauais and Pecém Beach, living *D. striatus* were also collected in the same sandy beach habitats.

Growth series of well preserved specimens of both *D. striatus* and *D. gemmula* from Ceará were photographed by a Zeiss “Axiocam MRc 5” camera coupled to a Zeiss “Stereo Discovery V8” stereomicroscope, for comparison of their shells along ontogeny (Figures 2-5). The contour of the valves of individuals smaller than ~2 mm in length is very similar in both species when viewed from the external or internal surfaces (Figure 2A-F). A distinct external posterior surface, which is detached from the lateral surface by the presence of a carina running from the umbones to the ventro-posterior margin of each valve,

is typical of wedge shaped *Donax* spp., being absent in the subglobose shell of *D. gemmula* (Figures 3A, 4A and 5A). In *D. striatus*, this distinct external posterior surface is only observed in individuals larger than ~2 mm in length (Figures 3D, 4D and 5D). When viewed from the internal surface, some additional differences can also be observed, such as the marginal crenulations of the valves, which in *D. gemmula* are more uniform, while in *D. striatus* they are more pronounced in the ventro-posterior margin, this becoming evident from ~2 mm onwards. The hinge structure is very similar among smaller individuals, the hinge teeth being slightly more developed in adults of *D. gemmula* than in those of young *D. striatus*. The shells and soft parts of the specimens of *D. gemmula* from Ceará were also compared with animals of this same species from the State of São Paulo (“ZUEC BIV 4076”); they are identical and thus considered conspecific. Most examined samples of *D. striatus* and *D. gemmula* from Ceará are deposited in the

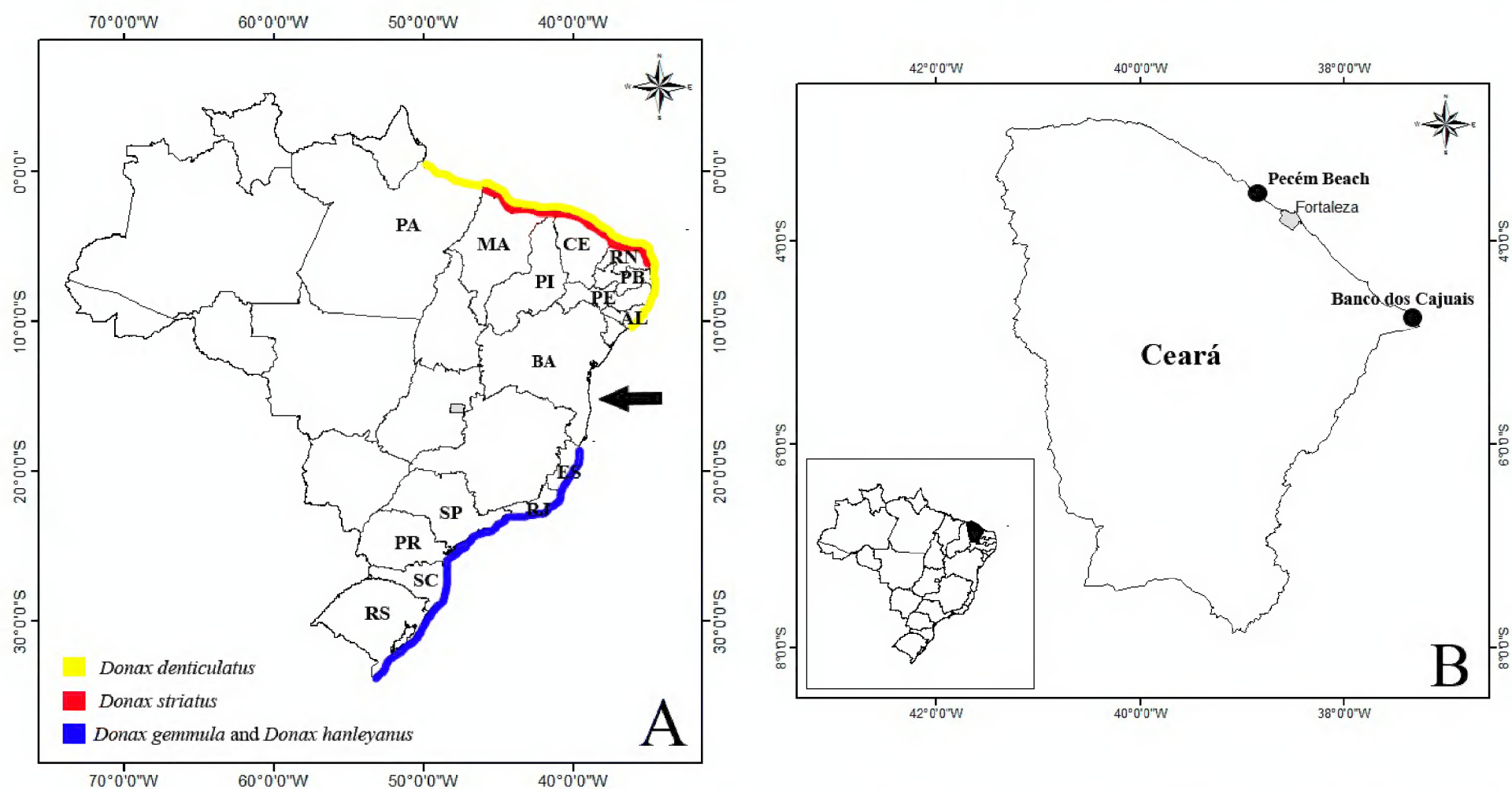


FIGURE 1. A, Geographic distribution of *Donax* in the Brazilian coast. The arrow points to Ilhéus, Bahia, where Ourives et al. (2011) recorded the occurrence of “*D. cf. gemmula*”. B, The State of Ceará, and the places where *D. gemmula* and *D. striatus* were collected in the present study: Banco dos Cauais and Pecém Beach.

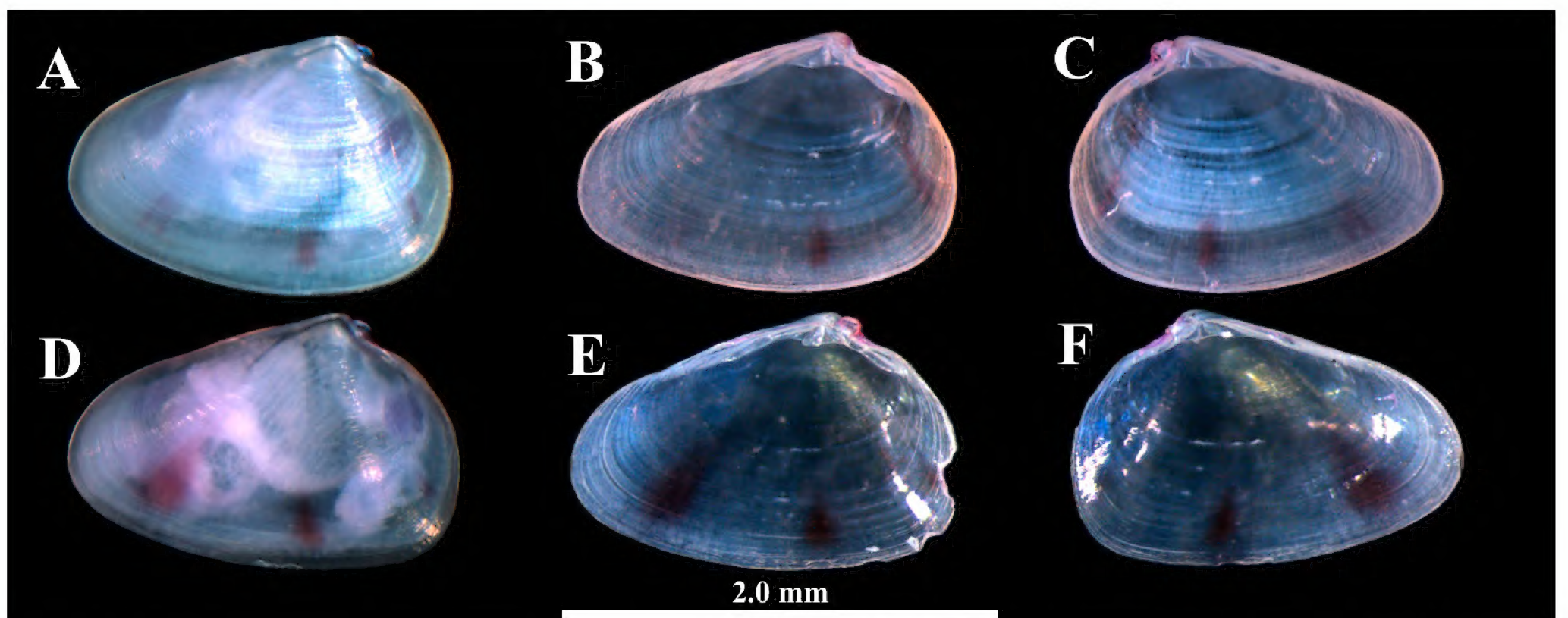


FIGURE 2. Shells of *Donax gemmula* “CMPHRM 3984B” (A-C) (1.75 mm in length) and *D. striatus* “CMPHRM 3980B” (D-F) (1.80 mm in length). A and D, External view of the left valve. B and E, Internal view of the right valve. C and F, Internal view of the left valve.

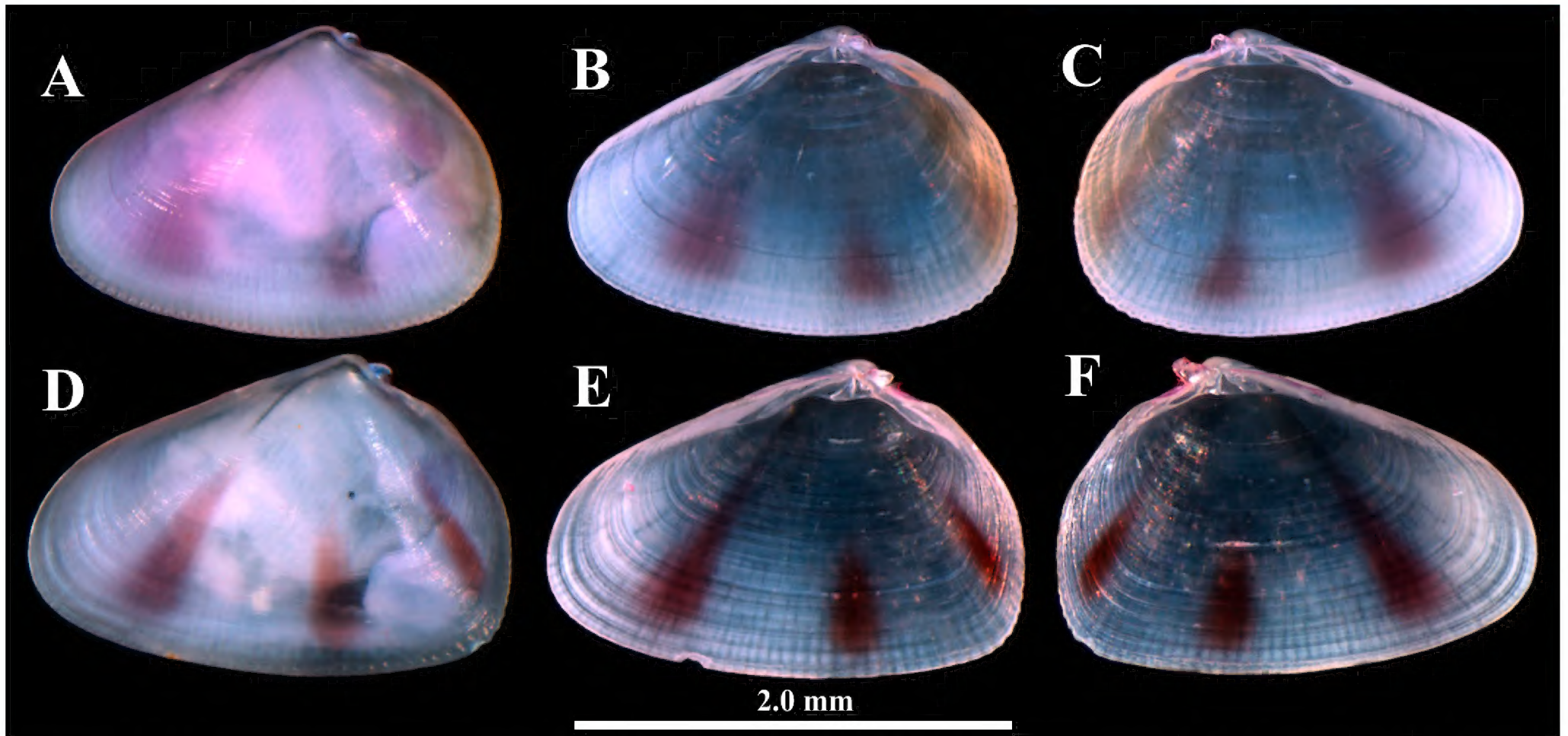


FIGURE 3. Shells of *Donax gemmula* “CMPHRM 3985B” (A-C) (2.07 mm in length) and *D. striatus* “CMPHRM 3981B” (D-F) (2.18 mm in length). A and D, External view of the left valve. B and E, Internal view of the right valve. C and F, Internal view of the left valve.

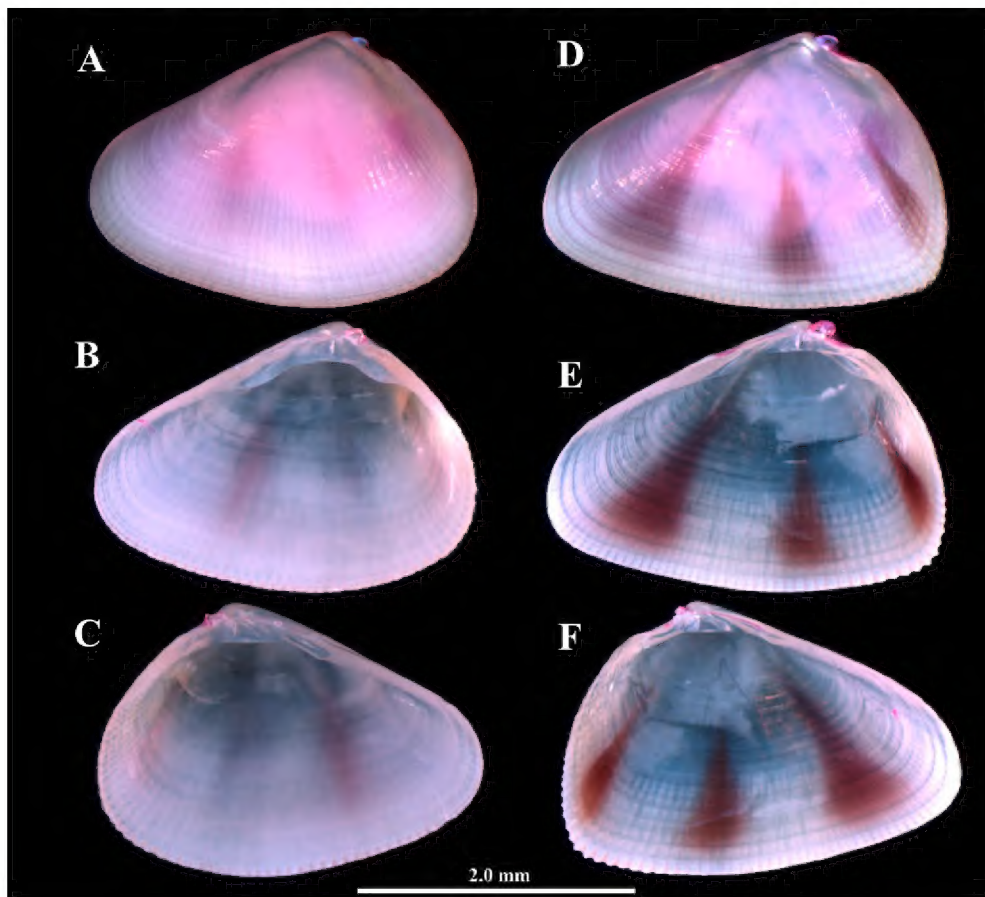


FIGURE 4. Shells of *Donax gemmula* “CMPHRM 3986B” (A-C) (2.77 mm in length) and *D. striatus* “CMPHRM 3982B” (D-F) (2.88 mm in length). A and D, External view of the left valve. B and E, Internal view of the right valve. C and F Internal view of the left valve.

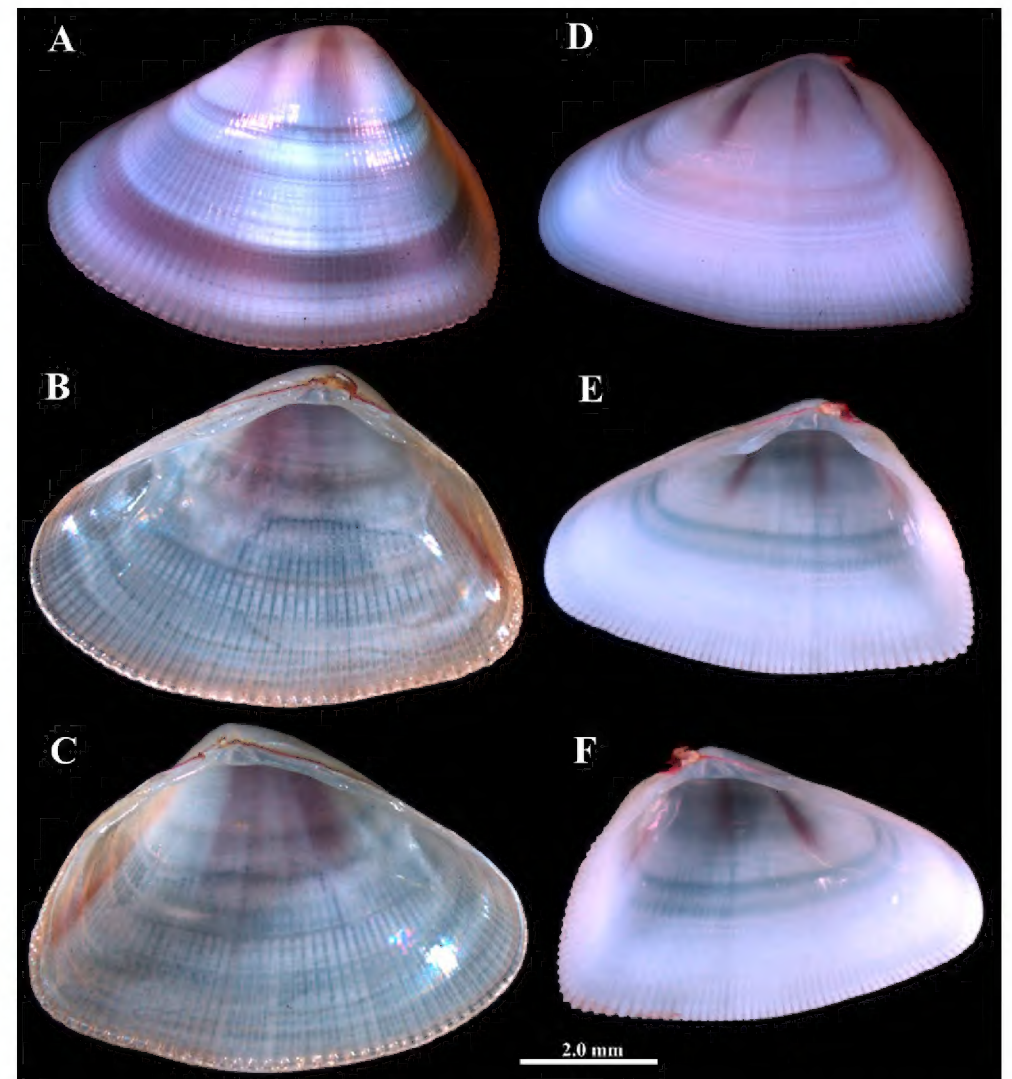


FIGURE 5. Shells of *Donax gemmula* “CMPHRM 3988B” (A: 6.57 mm in length) and “CMPHRM 2695B” (B-C: 7.22 mm in length), and of *D. striatus* “CMPHRM 3978B” (D-F) (6.31 mm in length). A and D, External view of the left valve. B and E, Internal view of the right valve. C and F Internal view of the left valve.

Malacological Collection “Prof. Henry Ramos Matthews” - Series B of the Universidade Federal do Ceará (CMPHRM-B) (“CMPHRM 3978B”, “CMPHRM 3980B” to “3983B” of *D. striatus*; and “CMPHRM 2692B”, “CMPHRM 2695B”, “CMPHRM 2720B”, “CMPHRM 3979B”, “CMPHRM 3984B” to “3989B” of *D. gemmula*), the remaining lots belonging to the Museu de Zoologia “Prof. Adão José Cardoso” of the Universidade Estadual de Campinas (“ZUEC BIV 4073” of *D. striatus*; and “ZUEC BIV 4074” to “4075” of *D. gemmula*).

There are two possible explanations for the finding of *D. gemmula* in Ceará State. The first is related to the possibility of a recent introduction by ballast water, as there is an intense ship traffic generated by petroliferous activities in Icapuí, and by the offshore seaport in Pecém Beach. In the marine environment, the main vectors for introduction of exotic species are ballast water of ships,

incrustations, and importation of exotic species for food and by the aquarium-fish trade (Silva *et al.* 2004; Amaral and Jablonski 2005). According to Amaral and Jablonski (2005), one of the greatest threats to marine biodiversity is the introduction of exotic species, combined with destruction of habitats and overexploitation for human consumption.

The second hypothesis is that *D. gemmula* occurs along the entire Brazilian coast, or at least from Ceará to Rio Grande do Sul. Several factors could be related to the non-detection or non-identification of *D. gemmula*

from the Northeastern Brazil until now. First, it is a small bivalve, not easily collected (bottom samples need to be sieved to obtain them), and may be confused with young specimens of other species of *Donax*, such as *D. striatus* and *D. hanleyanus*. Similarly to the shoreline of Ceará, all the remaining northeastern coast of Brazil bears a great diversity of biomes, with exposed sandy beaches (the typical habitat of *Donax* spp.) occurring scattered throughout this region of the Brazilian littoral. Ecological studies are fewer in the northeastern than in the southeastern and southern coast, this being particularly true for benthic communities of the infralittoral, where *D. gemmula* can be abundant.

If the first hypothesis is right, *D. gemmula* may have a disjunct geographic distribution, the population from Ceará being perhaps isolated from those of the southeastern and southern coast. On the other hand, if *D. gemmula* occurs along the entire northeast, this species has a continuous distribution. Future collections and also molecular studies will prove as useful in testing both hypotheses.

ACKNOWLEDGMENTS: The authors thank Dr. Ricardo S. Absalão, Dr. José Eduardo Amoroso Rodriguez Marian and Dra. Inês Xavier Martins for valuable comments on the manuscript. Part of this study was supported by the United States Fish and Wildlife Service (Neotropical Migratory Conservation Act) through a grant to Associação de Pesquisa e Conservação de Ecossistemas Aquáticos (Aquisis).

LITERATURE CITED

- Alves, E.S. and P.R. Pezzuto. 2009a. Effect of cold fronts on the benthic macrofauna of exposed sandy beaches with contrasting morphodynamics. *Brazilian Journal of Oceanography* 57(2): 73-96.
- Alves, E.S. and P.R. Pezzuto. 2009b. Effect of morphodynamics on annual average zonation pattern of benthic macrofauna of exposed sandy beaches in Santa Catarina, Brazil. *Brazilian Journal of Oceanography* 57(3): 189-203.
- Amaral, A.C.Z. and S. Jablonski. 2005. Conservation of marine and coastal biodiversity in Brazil. *Conservation Biology* 19(3): 625-631.
- Ansell, A.D. 1983. The biology of the genus *Donax*, p. 607-635. In A. McLachlan and T. Erasmus (ed.). *Sandy beaches as Ecosystems*. Boston: Dr. W. Junk Publishers.
- Arruda, E.P. and A.C.Z. Amaral. 2003. Spatial distribution of mollusks in the intertidal zone of sheltered beaches in southeastern of Brazil. *Revista Brasileira de Zoologia* 20(2): 291-300.
- Barros, F., C.A. Borzone and S. Rosso. 2001. Macroinfauna of six beaches near Guaratuba Bay, Southern Brazil. *Brazilian Archives of Biology and Technology* 44(4): 351-364.
- Borzone, C.A., J.R.B. Souza and A.G. Soares. 1996. Morphodynamic influence on the structure of inter and subtidal macrofaunal communities of subtropical sandy beaches. *Revista Chilena de Historia Natural* 69: 565-577.
- Campos, A.A. and M. Polette. 2003. A gestão integrada da Zona Costeira; p. 11-26 In AQUASIS - Associação de Pesquisa e Preservação de Ecossistemas Aquáticos (org). *A Zona Costeira do Ceará: Diagnóstico para a Gestão Integrada*. Fortaleza: Aquisis.

- Carlos, C.J., C.E. Fedrizzi, A.A. Campos, H. Matthews-Cascon, C.X. Barroso, S.G. Rabay, L.E.A. Bezerra, C.A.O. Meirelles, J. Meireles and P.R.L. Thiers. 2010. *Migratory Shorebird Conservation and Shrimp Farming in NE Brazil - Final Report*. 162 p.
- Cochôa, A.R., L. Lorenzi and C.A. Borzone. 2006. A influência da passagem de uma frente meteorológica na distribuição da macrofauna bentônica mesolitoral de uma praia arenosa exposta. *Tropical Oceanography* 34(2): 59-71.
- Corbisier, T.N. 1991. Benthic macrofauna of sandy intertidal zone at Santos estuarine system, São Paulo, Brazil. *Boletim do Instituto Oceanográfico de São Paulo* 39(1): 1-13.
- Denadai, M.R., A.C.Z. Amaral and A. Turra. 2005. Structure of molluscan assemblages in sheltered intertidal unconsolidated environments. *Brazilian Archives of Biology and Technology* 48(5): 825-839.
- Domaneschi, O. and S.G.B.C. Lopes. 1988-89. Família Donacidae Fleming, 1828. *Informativo da Sociedade Brasileira de Malacologia* 87: 9-12; 88: 9-12; 92: 9-12; 93: 9-12.
- Morrison, J.P.E. 1971. Western Atlantic *Donax*. *Proceedings of the Biological Society of Washington* 83(48): 545-568.
- Neves, F.M. and C.E. Bemvenuti. 2009. Variabilidade diária da zonação da macrofauna bentônica em praias arenosas do litoral norte do Rio Grande do Sul. *Iheringia Série Zoologia* 99(1): 71-81.
- Neves, F.M., L.A. Colling, P. de S. Pereira and C.E. Bemvenuti. 2006. Daily variation of macrobenthic fauna on an exposed sandy beach of Rio Grande do Sul, Brazil. *Journal of Coastal Research* 39: 1225-1228.
- Neves, L.P., P.S.R. da Silva and C.E. Bemvenuti. 2008. Temporal variability of benthic macrofauna on Cassino beach, southernmost Brazil. *Iheringia Série Zoológica* 98(1): 36-44.
- Neves, L.P., P.S.R. da Silva and C.E. Bemvenuti. 2012. Distribuição horizontal da macrofauna bentônica na praia do Cassino, extremo sul do Brasil. *Iheringia Série Zoologia* 102(3): 245-253.
- Ourives, T.M., A.E. Rizzo and G. Boehs. 2011. Composition and spatial distribution of the benthic macrofauna in the Cachoeira River estuary, Ilhéus, Bahia, Brazil. *Revista de Biología Marina y Oceanografía* 46(1): 17-25.
- Pagliosa, P.R. 2006. Distribuição da macrofauna benthica do entremarés ao sublitoral em uma praia estuarina da Baía da Babitonga, Sul do Brasil. *Biotemas* 19(1): 25-33.
- Passos, F.D. and O. Domaneschi. 2004. Biologia e anatomia funcional de *Donax gemmula* Morrison (Bivalvia, Donacidae) do litoral de São Paulo, Brasil. *Revista Brasileira de Zoologia* 21(4): 1017-1032.
- Silva, J.S.V., F.C. Fernandes, R.C.C.L. Souza, K.T.S. Larsen and O.M. Danelon. 2004. Água de lastro e bioinvasão; p. 1-10 In J. S. V. Silva and R. C. C. L. Souza (org.). *Água de Lastro e Bioinvasão*. Rio de Janeiro: Interciências.
- Silva, P. de S.R., L.P. Neves and C.E. Bemvenuti. 2008. Temporal variation of sandy beach macrofauna at two sites with distinct environmental conditions on Cassino Beach, extreme southern Brazil. *Brazilian Journal of Oceanography* 56(4): 257-270.
- Smith, A.J. and J.O. Morais. 1984. Estudos preliminares sobre a geologia ambiental costeira do estado do Ceará, nordeste do Brasil. *Arquivos de Ciências do Mar* 23(1): 85-96.
- Souza, J.R.B. and N.M. Gianuca. 1995. Zonation and seasonal variation of the intertidal macrofauna on a sand beach of Paraná State, Brazil. *Scientia Marina* 59(2): 103-111.

RECEIVED: August 2013

ACCEPTED: September 2013

PUBLISHED ONLINE: October 2013

EDITORIAL RESPONSIBILITY: Luis Ernesto Arruda Bezerra